WOOD PRODUCTION AND CONVERSION IN EASTERN ONTARIO

Summary Report

Report prepared for the
ONTARIO MINISTRY OF ENERGY

Ontario
Ministry of Energy
Honourable Robert Welch Q.C.
Minister

Energy Ontario

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Report prepared for the
ONTARIO MINISTRY OF ENERGY
by
Peat, Marwick and Partners
Management Consultants

Toronto, Ontario
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TABLE OF CONTENTS

		PAGE
EXECUTIVE SUMMARY		i
I	INTRODUCTION	1-3
	Background	1
	Approach	2
II	WOOD SUPPLY, CONVERSION TECHNOLOGY AND MARKETS	4-10
	Wood Supply and Cost Assessment	4
	Review of Wood Conversion Technologies	7
	Market Prospects for Wood-Derived Energy	9
III	PRELIMINARY TECHNICAL AND ECONOMIC ASSESSMENT OF WOOD CONVERSION	11-15
	Background	11
	Wood Requirements	12
	Proposed Plants	13
	Conclusions	14
IV	RELATED STUDIES AND PROJECTS	16-20
	Algonquin Region Fuel Wood Report	16
	Wood Heating in Institutional and Public Buildings	17
	Fuel Wood Consumption in Ontario	18
	Wood Conversion Project in the Forest Industry	19
V	NEW POLICY INITIATIVES	21-24
	Oil Price Agreement	21
	Conversion Grants	22
	A Greater Role for Wood Biomass Energy	22
VI	DIRECTIONS FOR FUTURE ACTION	25-27
	The Development of the Fuel Wood Infrastructure	25
	Completion of the Feasibility Study on Energy Conversion Plants	26
	Site Selection for Cogeneration Facility	27
	Conversion of Existing Methanol Plant	27
	Improvement in Plantation Productivity	28
	REFERENCES	29
	Appendix - Conversion Factors	30

TABLE OF CONTENTS - CONTINUED

EXHIBITS

		Opposite Page	Following Page	Page
Key Map of Wood Study Area		4		
Table 2.1:	An Estimate of the Annual Available, Substainable Natural Biomass Volumes	5		
Table 2.2:	Total Delivered Cost for Natural Wood Biomass (1980 $)	6		
Table 2.3:	Hybrid Poplar Plantation Biomass: Summary of Estimated Costs by Cutting Cycle		6	
Table 2.4:	Wood Supply Potential at Alternative Price (1980 $)		6	
Table 3.1:	Wood Supply Requirements 1990	12		
Table 3.2:	Summary of Engineering Analysis			13
Table 3.3:	Cost Comparisons of Energy from Wood with Conventional Energy	14		
Table 4.1:	Summary Results of Study on Wood Burning in Institutional Buildings	18		
Table 5.1:	Canadian Oil Price Schedule, 1982-1986	21		

ABSTRACT

WOOD PRODUCTION AND CONVERSION IN EASTERN ONTARIO

SUMMARY REPORT

Peat, Marwick and Partners was retained by the Ontario Ministry of Energy to investigate the technical and economic feasibility of converting wood into energy in Eastern Ontario. This report:

1. Summarizes major findings and conclusions regarding (a) wood supply availability and costs and (b) the technical and economic feasibility of converting wood into energy.

2. Reviews recent policy initiatives aimed at reducing oil consumption and comments on the implications for wood-derived energy.

3. Provides suggestions for further study and/or action with regard to specific wood-energy projects in Eastern Ontario.

EXECUTIVE SUMMARY

The Ontario Ministry of Energy has identified immediate and long-term opportunities for the the conversion of wood waste into fuel. In a March 24, 1980 policy statement, Energy from Waste: A Program for Ontario, the Ministry of Energy stated that, using currently feasible technology, more than 2% of Ontario's total energy supply could be produced annually by 1995 from currently utilized wood residues and wood (hybrid poplar) energy plantations. The counties of Leeds, Grenville, and Lanark in Eastern Ontario have been identified as areas with a potential for supply of wood for conversion into steam, electricity, or liquid fuel.

SCOPE OF STUDY

This study was initiated in June, 1980 by the Ontario Ministry of Energy in cooperation with the Ministry of Natural Resources and the Ministry of Treasury and Economics to investigate the technical and economic feasibility of converting wood into energy in these three counties. The purpose of this final summary report is:

- to summarize the major findings and conclusions of the feasibility study,
- to comment on the implications of recent policy initiatives for the development of a wood energy industry in Eastern Ontario, and
- to offer suggestions for future study in the development of a wood energy industry in Eastern Ontario.

WOOD SUPPLY

The area is capable of generating over 1 million oven-dried tons (ODT) of wood per year at a cost (in 1980 $) of approximately $50 per ODT on a sustained yield basis. The source of this supply includes: industrial wood residues,

logging residues, natural wood from public and private woodlands, and, wood from hybrid poplar plantations. The wood supply estimates show that the Eastern Ontario region is capable of meeting the demands of:

- a 9 MW plant producing steam and electricity, requiring 146,000 ODT per year,
- a 60 tons per day methanol plant requiring 46,000 ODT per year, and
- the domestic, commercial and industrial heating market in the region consuming up to 404,000 ODT by 1990.

WOOD ENERGY CONVERSION

It is technically feasible, using commercially available techniques, to develop a power plant to generate electricity and steam and to employ a prototype gasification system developed by Omnifuel Gasification Systems Ltd. to produce methanol. The development of a 9MW cogeneration facility, generating power at an estimated cost of 2.7¢/kwh, appears to be economically attractive. Although the economics of producing methanol at 60 tons per day are not favourable (cost of 40¢/litre) at this time, the study notes the importance of such a demonstration project to develop the full potential for methanol derived from wood. Perth, Carleton Place, and Edwardsburgh are proposed as possible sites for the location of the energy plants.

FUELWOOD MARKET

We examined the current and future demand for fuel wood for heating residential, commercial and institutional buildings in the area. Wood requirements are estimated to increase from 330,250 ODT per year in 1980 to 404,000 ODT by the year 1990.

A series of studies has been conducted by the Ontario Ministry of Energy and the Ontario Ministry of Natural Resources to increase the factual information

regarding all aspects of fuel wood use in the region. These studies demonstrate the growing demand for fuel wood in households and institutional buildings and suggest that the prospects for developing a fuel wood industry are encouraging.

NEW POLICY INITIATIVES

These prospects are further enhanced as a result of recent policy initiatives by government to promote the substitution of oil by alternative fuel sources, including wood biomass. These initiatives include:

- National Energy Program (NEP) and the effects of the oil price agreement of September, 1981;
- provision of Federal grants to consumers to offset some costs of conversions to non-oil fuel sources;
- Forest Industry Renewable Energy (FIRE) program which provides incentives to utilize wood waste as a source of fuel;
- Energy from Forest (ENFOR) program which assist new research and development in wood biomass energy;
- Federal-Ontario bilateral program providing funding to wood utilization projects.
- Ontario Industrial Energy Conservation and Oil Substitution Incentive Program.

OUTLOOK

Some aspects of developing the wood-energy industry in Eastern Ontario require further study. In particular, the following matters need to be investigated:

- the development of a reliable distribution and marketing system for fuel wood;

- the institutional factors which will influence the long run prospects of using wood to produce energy, including those factors affecting ownership, operation, and marketing of wood-derived energy;

- the suitability of particular sites for the possible cogeneration facility in the region;

- the technical and economic feasibility of converting an existing methanol plant using naptha as feedstock to one using wood combined with natural gas as feedstock.

1.0 - INTRODUCTION

1.1 - BACKGROUND

The growing dependence on offshore oil has sparked considerable interest in the substitution of more available indigenous energy forms. Wood offers opportunities as a fuel for industrial steam and electricity generation, as a raw material used in the process of manufacturing methanol and ethanol, and as a fuel for direct combustion in residential, commercial and industrial heating systems. While researchers and energy policy-makers recognize the opportunities in the use of wood for fuel, they are, at the same time, aware of the enormous technical and economic challenges which lie ahead. Wood gasification technology awaits commercial success; distribution systems for the development of a fuel wood market are lacking; and widespread acceptance of wood as an alternative fuel by the public and industry has not yet arrived. Nevertheless, rapid changes in the relative cost of conventional energy sources require a continual re-appraisal of the economics and industrial development aspects of wood-based energy systems.

Within this context, the Ontario Ministry of Energy in cooperation with the Ministries of Natural Resources and Treasury and Economics commissioned this study to assess:

1. The potential for supplying wood material derived from a variety of sources in Eastern Ontario.

2. The technological and economic feasibility of wood biomass utilization for energy production with a view to substituting for conventional energy sources.

3. A preliminary assessment of the economic cost/benefit aspects of proceeding with word energy development in Eastern Ontario.

Eastern Ontario has several characteristics which justify a close study:

- o considerable unutilized land is available under both private and public ownership and;
- o recent studies [1,4] suggest the region would make a good area for hybrid poplar production, a wood considered to be the most promising for wood biomass energy plantations;
- o transport and other infrastructure are well developed in the area; and
- o an adequate and suitable labour force appears to be available.

In July 1980, the Ontario Ministry of Energy selected a consulting team led by Peat, Marwick and Partners, which included Shawinigan Energy Consultants Ltd., and C.D. Schultz and Company Limited, to undertake this study. In addition, the study team benefited from the advice of W.W. Hall of Opeongo Forestry Services, Renfrew, Ontario.

1.2 - APPROACH

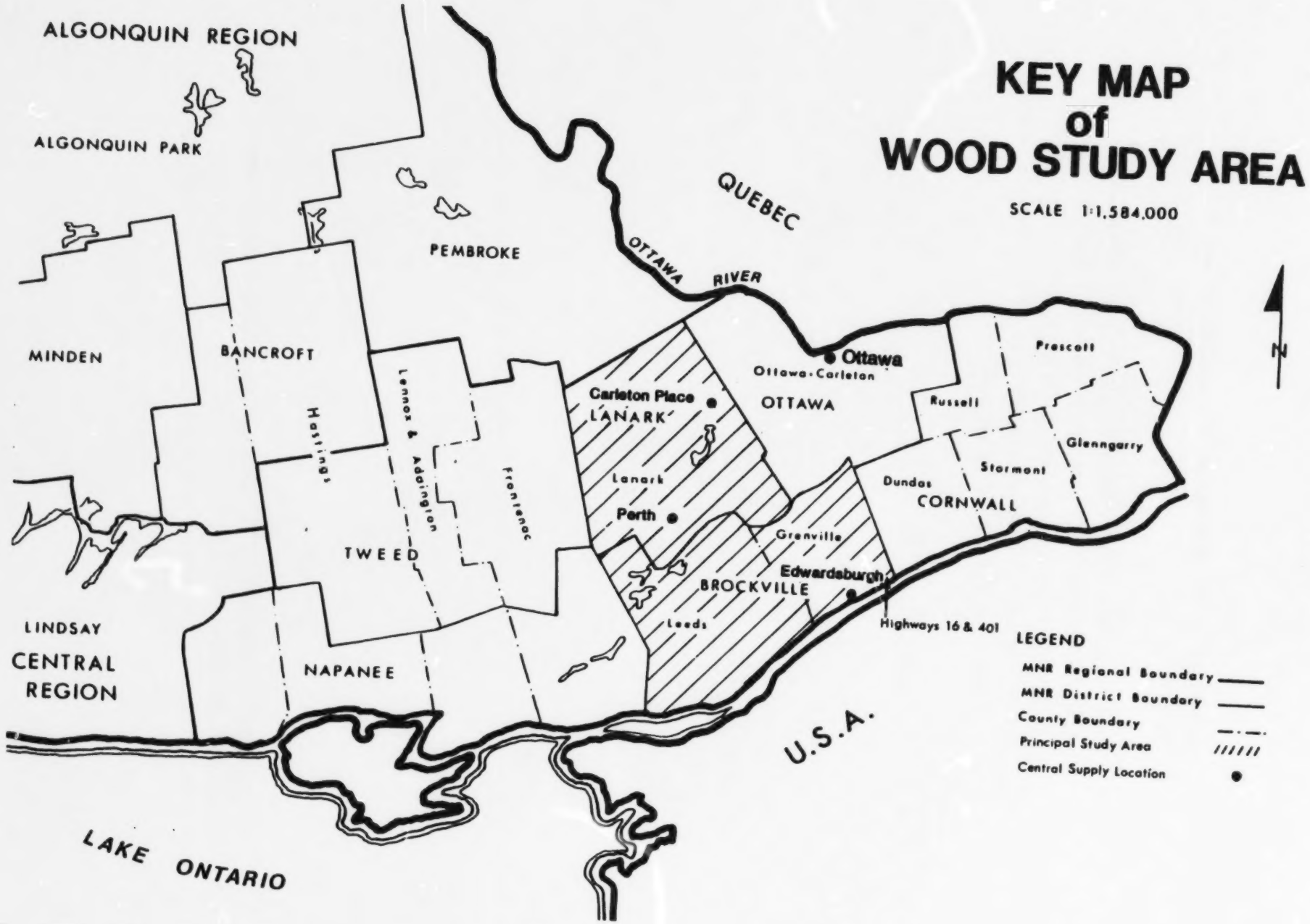
The study was conducted in three phases, as follows:

- o Phase I assessed the potential supply of wood in Eastern Ontario, reviewed the conversion technology, examined the major physical distribution issues, and determined the market opportunities for wood-derived energy.[1]
- o Phase II provided preliminary engineering design and cost estimates for the construction and operation of a steam turbine plant, a cogenerating plant for the production of steam and electricity, and a demonstration-scale methanol plant using wood as a feedstock. It

also examined the development of a fuel wood* supply system.[2]

- Phase III, this final report, summarizes the results of two previous technical reports[1,2], comments on recent changes in national energy policy and the implications for the development of wood energy, builds on concurrent relevant studies in Ontario, and suggests areas for further study and/or action.

* Fuel wood is used to refer to wood produced for domestic, commercial and industrial heating.


KEY MAP
of
WOOD STUDY AREA
SCALE 1:1,584,000
ALGONQUIN REGION
ALGONQUIN PARK
PEMBROKE
QUEBEC
OTTAWA RIVER
MINDEN
BANCROFT
Haliburton
Lennox & Addington
Frontenac
Carleton Place
LANARK
Ottawa
Ottawa-Carleton
OTTAWA
Prescott
Russell
Glengarry
Stormont
Dundas
CORNWALL
Lanark
Perth
TWEED
Grenville
Edwardsburgh
BROCKVILLE
Leeds
Highways 16 & 401
LINDSAY
CENTRAL
REGION
NAPANEE
U.S.A.
LAKE ONTARIO
N
LEGEND
MNR Regional Boundary
MNR District Boundary
County Boundary
Principal Study Area
Central Supply Location

2.0 - WOOD SUPPLY, CONVERSION TECHNOLOGY AND MARKETS

This section reports on study results concerning the supply and cost of wood, the technology of converting wood into energy and the potential market for wood-derived energy in Eastern Ontario.

2.1 WOOD SUPPLY AND COST ASSESSMENT

The terms of reference for the wood supply analysis were as follows:

1. The identification of the sustainable annual wood supply potential and the estimation of delivered cost per oven-dried ton (ODT) within a 25-mile radius of the junction of Highway 401 and Highway 16 and for two other locations within the counties of Lanark, Leeds, and Grenville.

2. The quantification of sustainable annual amount of volumes of wood which can be supplied at these three locations for an estimated cost of: a) $50 per ODT; b) $75 per ODT; c) $100 per ODT (1981 $).

3. An analysis of the anticipated production and harvesting costs per acre of hybrid poplar grown in the area based on a 500-acre plantation.

In all cases, wood available from privately owned land was identified separately from wood available from Crown land. Initially, the study encompassed the counties of Leeds, Grenville, and Lanark, but as the project continued, it became apparent that the three counties could not provide an adequate wood supply. Therefore, the scope of the project was enlarged to include all of the Ontario Ministry of Natural Resources Eastern Region of Ontario together with much of Pembroke and Bancroft districts (see key map, opposite).

Table 2.1

AN ESTIMATE OF THE
ANNUAL AVAILABLE, SUSTAINABLE, NATURAL BIOMASS VOLUMES
BY
DISTRICT, COUNTY TENURE

VOLUMES IN OVEN DRIED TONS (TONNES)*

District	County	Patent		Crown		Agreement Forests & Others		Total	
Brockville	Grenville	6,370	(5,780)	260	(240)	140	(120)	6,770	(6,140)
	Leeds	22,650	(20,550)	330	(300)	10	(10)	22,990	(20,860)
Lanark	Lanark	32,910	(29,860)	2,730	(2,470)	440	(400)	36,080	(32,730)
Pembroke	Renfrew	33,840	(30,700)	41,970	(38,080)	-	-	75,810	(68,780)
Cornwall	Russell	1,300	(1,180)	-	-	740	(670)	2,040	(1,850)
	Prescott	4,710	(4,280)	-	-	170	(150)	4,880	(4,430)
	Dundas	3,910	(3,540)	-	-	-	-	3,910	(3,540)
	Stormont	4,780	(4,330)	-	-	-	-	4,780	(4,330)
	Glengarry	3,840	(3,480)	-	-	-	-	3,840	(3,480)
Ottawa	Ottawa - Carleton	10,730	(9,730)	-	-	230	(210)	10,960	(9,940)
Tweed	Lennox & Addington	12,520	(11,360)	18,310	(16,610)	-	-	30,830	(27,970)
	Frontenac	25,830	(23,430)	13,340	(12,100)	-	-	39,170	(35,530)
	Hastings	41,690	(37,820)	14,370	(13,040)	-	-	56,070	(50,860)
Napanee	Lennox & Addington	5,070	(4,600)	5,250	(4,760)	-	-	10,330	(9,360)
	Frontenac	12,910	(11,710)	1,770	(1,610)	-	-	14,680	(13,320)
Bancroft	Hastings	83,660	(75,890)	-	-	-		83,660	(75,890)
Total		306,720	(278,240)	98,330	(89,210)	1,730	(1,560)	406,800	(369,010)

* Logging residues not included

The study considered a number of different sources of wood biomass, including:

- natural wood,
- industrial forest residues (eg., sawmill chips and bark),
- logging residues,
- salvage of dead timber as a result of fire, insect and disease damage,
- stand conversion and improvement, and
- hybrid poplar plantations.

We developed supply data based upon data from the Ontario Ministry of Natural Resources regarding forest inventories, land tenure, forest industry activity and hybrid poplar plantations. The existing wood biomass data was applied to forest stands within the study area to create "wood biomass classes". These classes were then, in turn, used to assess the volumes available in each district and county. In addition, data were incorporated from Federal Government sources and industry officials in Eastern Ontario. Finally, the consultants spent nearly two months in the region conducting a field assessment of the resource base.

2.1.1 Natural Wood Biomass

Natural wood inventory was identified by district, county and tenure. Not all wood resources revealed in this inventory would be available for conversion into energy. Some wood is already committed under various Crown Timber Licenses, Forests Agreement, and Conservation areas. Also, not all private land-owners would necessarily be prepared to sell from their woodlots. Moreover, it would be unlikely that much softwood would be available for energy conversion, since saw logs and pulpwood can command attractive prices in the forest industry.

Accordingly, the original inventory data for private and Crown lands was reduced to reflect the realistic potential supply available in the region. Table 2.1, opposite, summarizes available natural wood biomass by administrative district, by county and by type of land tenure.

TABLE 2.2

TOTAL DELIVERED COST FOR NATURAL FOREST BIOMASS
(1980 $)

	Edwardsburgh	Perth	Carleton Place
Weighted average cost at roadside per oven-dried ton	$20.74	$20.74	$20.74
Stumpage/ODT	$ 6.00	$ 6.00	$ 6.00
Weighted average one-way haul distance	117 mile	71 mile	80 mile
Cost/ODT loaded mile	$0.119	$0.170	$0.153
Chip hauling cost	$13.92	$12.07	$12.24
Total Delivered Cost per ODT	$40.66	$38.81	$38.98
Approx. cost $/GJ	$ 2.23	$ 2.13	$ 2.14

In calculating estimates of delivered costs of natural forest biomass to the three proposed central supply locations, we prepared cost estimates for harvesting, transportation and stumpage. These estimates are presented in Table 2.2, opposite.

2.1.2 Residues

The study also explored, in a manner similar to the analysis conducted for natural forest biomass, the potential supply and cost of obtaining wood residues for energy conversion. Currently, industrial wood residues, e.g., sawmill and pulpmill waste, are being discarded, burned on site, or put into land fill. Estimates of the supply available for energy conversion were made in light of current use of residues and the expected increase in recycling by the forest products industry (e.g., hog fuel). Although logging residues produced annually in the area are estimated to run as high as 133,000 ODT, (Table 2.4) their availability is considerably reduced by the fact that present harvesting techniques are not conducive to their recovery, and a higher recovery rate of this resource remains to be achieved in the future. Thus, available logging residues were estimated at somewhat reduced levels.

2.1.3 Wood Biomass Farming

The final potential source of wood biomass supply is wood produced on plantations. We considered the percentage of private land which could be attracted into wood farm management, the cost of the land and the expected yields from hybrid poplar based upon various rotation cycles. Table 2.3, following, summarizes the estimated costs by cutting cycles of hybrid poplar plantations which could deliver wood biomass in the three proposed central supply locations.

2.1.4 Wood Supply at Alternative Prices

Table 2.4, following, identifies sources of wood biomass that would become available to all consumers at alternative prices from $20 per ODT to $100 per ODT in each of the three locations under review - Carleton Place, Perth, Edwardsburgh.

Table 2.3

HYBRID POPLAR PLANTATION BIOMASS
SUMMARY OF ESTIMATED COSTS BY CUTTING CYCLE*
FOR THREE PROPOSED PLANT SITES
1980 DOLLARS

Description	Edwardsburgh $/Cutting Cycle('000)	Edwardsburgh $/Acre	Perth $/Cutting Cycle('000)	Perth $/Acre	Carleton Place $/Cutting Cycle ('000)	Carleton Place $/Acre
Cost of Establishment per cutting cycle	337.50	50	340.00	50	375.50	50
Land rent per cutting cycle	438.75	91	442.00	91	464.75	91
Interest on operating capital per cutting cycle	1,316.25	164	1,326.00	164	1,394.25	164
Herbicide & fertilizer application per cutting cycle	405.00	60	408.00	60	429.00	60
Harvesting	1,775.00	260	1,768.00	260	1,859.00	260
Transport	762.75	113	768.40	113	800.80	112
Cost Per Acre** delivered to Plant	5,015.25	738	5,052.40	737	5,305.30	738
Total Cost of Establishment	1,676.0	250	1,689.0	250	1,744.5	250
Cost per ODT delivered to Plant		42.20		42.20		42.10

* Based on 6.5 year midi rotation and 5' x 5' spacing and average annual yield of 3 ODT/acre/year.

** The following acreages were assumed: Edwardsburgh (6,750 acres); Perth (6,800 acres) and Carleton Place (7,150 acres).

It can be anticipated that a minimum delivered supply price of $50 per ODT would immediately attract all pulpwood, wood chips, and other mill residues within approximately a 150-mile radius of each location. At this same price, approximately 406,800 tons of wood would be attracted from natural forests and, in addition, approximately 50% of the unutilized private land in the region would be attracted into wood farming, i.e., energy plantations. At a price of $75 per ODT, we could anticipate that additional wood would be supplied from chips, pulpwood and hybrid poplar and from approximately 20% of unutilized marginal private land. Finally, were wood prices to reach a level of $100, we could anticipate that all the remaining private land would be converted into hybrid poplar plantations. In total, the impact of higher prices on wood supply would result in a supply ranging from 1,614,700 to 1,876,800 ODT per year at a price of $100 per ODT.

The enlarged area is capable of generating over 1 million ODT per year at a cost of approximately $50 per ODT. The source of this supply is:

- 400,000 ODT of natural wood,
- 320,000 to 450,000 tons from hybrid poplar plantations,
- 115,000 tons from industrial forest residues,
- 130,000 tons from logging residues.

Moreover, a hybrid poplar plantation of 500 acres located in the study area could economically deliver wood to a conversion facility at $50 per ODT.

Harvesting and distribution activities associated with the development of all these sources would create up to 300 direct new jobs. Total investment in these activities could range between $20 and $30 million.

2.2 REVIEW OF WOOD CONVERSION TECHNOLOGIES

We reviewed many technologies for converting wood biomass to produce steam, electricity and methanol.

TABLE 2.4

WOOD SUPPLY POTENTIAL AT ALTERNATIVE PRICES
(1980 $)

Price $/ODT	$/GJ Equivalent	Wood Source	Location: Carleton Place	Location: Perth	Location: Edwardsburgh
			(ODT/year)		
$20	$1.00	Industrial residues	51,500	51,500	51,500
$30	$1.65	Bark, sawdust	20,900	20,900	20,900
$40	$2.19	Logging residues	133,100	133,100	133,100
$50	$2.74	Natural	406,800	406,800	406,800
		Hybrid[1] poplar	450,300	381,500	319,400
$75	$4.11	Chips	159,300	159,300	159,300
		Pulpwood	204,600	204,600	204,600
		Hybrid poplar[2]	90,000	76,300	63,900
$100	$5.48	Hybrid poplar[3]	360,300	305,200	255,500
TOTAL SUPPLY AT $100/ODT			1,876,800	1,739,200	1,614,700

Notes: (1) Assumes only 50% of marginal or submarginal private land converted into plantations.

(2) Assumes 20% of the remaining private land is converted into plantations.

(3) Assumes all remaining private land converted into hybrid poplar plantations.

The practice of burning wood to heat large boilers to produce steam and electricity is well established in North America. Pulp and paper mills generate tremendous quantities of residue which, in the past, have been difficult to dispose of. However, with the relative increase in the price of conventional fuels, the industry has made significant strides in converting this residue into energy for steam and electricity production. In many areas, the North American forest products industry has been at the forefront of this conversion technology.

We assessed studies on wood-burning power-generation stations such as that on the Hearst wood waste energy complex[3], the Wayman study for the Royal Commission on Electric Power Planning[4], various studies by Ontario Hydro[5], and a study of the project currently under way in Burlington, Vermont. Based upon these studies, we concluded that a facility for raising steam or producing up to 50 MW of electricity from wood-burning is technically feasible. A facility of this size would require approximately 400,000 ODT of wood per year as feedstock.

Most of the studies done on wood-burning to date by various governments and firms have dwelt mainly on conventional steam generation. However, there has been a recent thrust by scientists and engineers to consider wood gasification systems which are designed to increase the energy produced from a ton of wood burnt.

Gasification is achieved by causing wood and air to react at high temperatures, resulting in hot gases which can subsequently be burned as a source of energy. In order to evaluate the technological feasibility of gasification, we contacted manufacturers, suppliers, government and research institutes and systems designers. The following manufacturers and research laboratories were contacted and processes for wood gasification and methanol synthesis were examined:

- Union Carbide Canada Limited/Purox system;
- Moore Canada Limited/Power Gas process;

- o Lurgi Canada/Methanol synthesis;
- o Omnifuel Gasification System/gasification process;
- o International Nickel Company Limited;
- o Ontario Research Foundation;
- o Battelle Columbus Laboratories;
- o Davy, McKee Incorporated;
- o Sultana Corporation;
- o Forintek Canada Corporation;
- o Applied Engineering Company;
- o Koppers-Totzek process, and
- o Cesp process (Brazil).

We evaluated the various gasification technologies, recognizing that not one process has achieved, as yet, commercial success. Difficulties in the evaluation process were encountered, especially in trying to validate claims made by various manufacturers. After a careful assessment, we concluded that the Omnifuel gasification system has real potential for commercial development. Moreover, this system is being used in a wood residue energy plant in Hearst. To the best of our knowledge, this is the first wholly commercial order for a wood gasifier, and it is thought to be the largest wood gasifier of any type ever built. Consequently, we developed an engineering analysis and cost estimates based upon the use of the Omnifuel gasifier in the production of methanol.

2.3 MARKET PROSPECTS FOR WOOD-DERIVED ENERGY

The market opportunities for the sale of steam, electricity and methanol in Eastern Ontario were also investigated. Four important conclusions were reached:

1. Market opportunities exist for electrical power and steam derived from wood-burning, including the sale of electrical power to the Eastern provincial grid and power and steam to specific industries in the region on a dedicated basis.

2. The production of methanol for use as a transportation fuel appears to be a viable long-term option with potential sales to the entire transportation market in Ontario.

3. There are opportunities for developing markets for fuel wood, especially in the commercial, institutional and residential heating sectors. This conclusion was reached as a result of comparing the economics of using wood with those of using conventional fossil fuels as a primary fuel.

4. In view of the anticipated significant increases in the price of oil and natural gas sold in Ontario over the longer run, it appears likely that wood's share of Eastern Ontario's energy market will increase steadily.

3.0 - PRELIMINARY TECHNICAL AND ECONOMIC ASSESSMENT OF WOOD CONVERSION

3.1 BACKGROUND

An engineering and preliminary cost analysis of the proposed plants for each location was undertaken by Shawinigan Energy Consultants.

The engineering work was conducted at a pre-feasibility level, using commercially available cost estimates for raw materials, capital equipment and labour. The study drew upon work previously conducted for the Hearst Wood Waste Energy Study[3]. The Hearst Study examined the feasibility of developing wood-burning plants of a slightly larger scale and of a somewhat similar design concept as proposed in this study and described in an earlier report[2].

This present study has been undertaken in somewhat different circumstances from those prevailing at the time of the Hearst study. Since the release of the Hearst study:

- the Ontario Government has strengthened its commitment to the integration of new energy sources into the Ontario Hydro System; in particular, energy from waste and wood wastes has been given higher priority in the Government's drive for greater self-sufficiency;
- world oil prices have more than doubled and Canadian oil prices have also risen, increasing the viability of a wood-fired industrial cogeneration energy plant;
- Ontario Hydro has undertaken a review of its policy towards the purchase of energy from non-conventional sources of power with a view to accommodating the development of wood-fired industrial cogeneration facilities.

TABLE 3.1

WOOD SUPPLY REQUIREMENTS, 1990

	Case A (ODT/yr)	Case B
10-MW Steam turbine plant	67,000	-
9-MW Cogeneration plant	-	143,640
60-TPD Methanol plant	46,000	46,000
Fuel Wood Market	404,000	404,000
TOTAL	517,000	593,640

The analysis represents a preliminary financial and economic assessment of the viability of each proposed energy plant under prevailing cost conditions in 1981. Future wood costs, fossil fuel prices and future interest charges and financial/ownership issues require further analysis in order to assess the probable longer term commercial success of each plant.

3.2 WOOD REQUIREMENTS

Estimates were derived for wood requirements for each proposed plant as well as for a fuel wood market in Eastern Ontario. These requirements were then assessed in terms of the current and potential available wood biomass supply in the area.

Table 3.1, opposite, summarizes the wood requirements for each energy plant and the fuel wood market for 1990. Since either the cogeneration plant or the steam turbine plant are proposed, but not both, we present demand estimates for two different cases.

Depending on which electricity generating plant is developed, total consumption would range from 517,000 to 593,640 ODT for 1990. This latter estimate represents approximately half of the available wood supply at $50/ODT, a third at $75/ODT and approximately 20 percent of the potential supply at $100/ODT.

Fuel wood requirements for the domestic, institutional and commercial markets are expected to increase from 330,250 ODT per year in 1980 to 404,000 ODT per year by 1990. These estimates were based upon conservative assumptions regarding future trends for alternative energy prices.

The outlook for fuel wood consumption is ennanced by the following:

- o although wood costs are expected to increase over the next decade, these cost increases should not exceed the general rate of inflation;

- o the increase in the cost of fossil fuels, especially oil, and to a lesser extent, natural gas, should exceed the annual increases in the rate of inflation;

- o there is growing interest in Eastern Ontario in using wood as a primary fuel for institutional and commercial facilities. (This important point is further discussed later in this report.)

3.3 PROPOSED PLANTS

The engineering analysis was conducted at the pre-feasibility level. The analysis incorporated process flow diagrams, plant layout diagrams, schematic diagrams of major capital equipment to be used, lists of capital equipment, and estimates of capital and operating costs. The results are summarized in Table 3.2, below.

Table 3.2

Summary of Engineering Analysis
(1981 $)

	Type of Facility		
	10MW Steam Turbine	9MW Cogeneration	60 Tons per Day Methanol
Capital Cost	$12.7 mill.	$16.4 mill.	$36.0 mill.
Annual Operating Cost	$ 3.2 mill.	$ 5.9 mill.	$ 4.0 mill.
Cost of Electricity (per kWh)	7.15¢	2.73¢	-
(per GJ)	$ 1.99	$ 0.76	
Cost of Steam (per MM BTU)	-	$ 4.89	-
(per GJ)		$ 4.64	
Cost of Methanol (per litre)	-	-	40¢

TABLE 3.3

COST COMPARISONS OF ENERGY FROM WOOD WITH CONVENTIONAL ENERGY, 1981

Source of Energy:		Cost
electricity from:	(¢/kWh)	($/GJ)
- 9MW cogeneration plant	2.73	0.76
- 10MW steam power plant	7.15	1.99
- Ontario Hydro *	2.86	0.79
methanol from:	($/MM BTUS)	
- natural gas	19.00	18.03
- wood in Eastern Ontario	23.60	21.82
gasoline based on:	($/MM BTUS)	
- domestic crude oil price	11.00	10.43
- average price of imported crude	30.00	28.46

* rate charged to municipalities in Eastern Canada

Source: Peat, Marwick and Partners, Wood Production and Conversion in Eastern Ontario, Phase II, August, 1981.

The development of a 9-MW cogenerating facility appears to be economically attractive. At an estimated 2.7¢/kWh, the cost of electricity produced by cogeneration from wood compares favourably with the 1981 cost of conventionally produced electricity in Eastern Ontario. The estimated cost of steam ($4.89 per MM BTU) also compares favourably with costs currently incurred by industrial users in Eastern Ontario. Electricity from the 10 MW steam turbine is not competitive with rates charged by Ontario Hydro and local municipalities, as indicated in Table 3.3, opposite.

Provided site conditions are suitable, this proposed plant could provide an excellent opportunity to demonstrate the economic feasibility of producing energy from wood in the region.

On an adjusted basis*, the methanol cost is $23.60 per million BTU's (1981 $) compared to a domestic gasoline price of $11.00 per MM BTU's and an estimated international price of $30.00 as shown in Table 3.3. As the domestic oil price moves towards international prices, the relative cost of producing methanol from wood will become increasingly attractive compared to the cost of gasoline. Methanol from natural gas in Western Canada must be considered as the base for Canadian methanol prices and given the current cost of $0.40/litre of methanol from wood on the scale envisioned the energy conversion process is not directly competitive. However, the combined natural gas/wood to methanol process may have a significant potential and is worth investigating in greater detail.

3.4 CONCLUSIONS

The following conclusions flowed from the preliminary analysis of the economics of wood conversion in Eastern Ontario.

1. The development of a 9-MW cogeneration facility is economically viable. Provided site conditions are suitable, such a facility could successfully demonstrate the opportunities for producing energy derived from wood in the region of Eastern Ontario.

* Adjusted for lower BTU content compared to gasoline and for higher efficiency when burned as straight methanol in specially designed engines.

2. A 10 MW wood-fuelled power generating plant is not economically viable.

3. Although the economics of producing methanol from wood are not favourable at this time, it is important to bear in mind that the project was under investigation primarily as a demonstration unit. In this regard, the project does hold some promise, in view of the fact that the production costs are not excessively high compared with the anticipated price of gasoline over the next two decades. Moreover, the unpredictability associated with future gasoline prices enhances the attractiveness of methanol derived from wood.

   In order to yield acceptable economic results, it is believed that the plant must have a capacity of between 600 to 2400 tons per day. The use of combined natural gas and wood feedstocks would lead to improved conversion efficiencies and economics.

4. The development of an energy complex comprising 9-MW cogeneration plant and a methanol plant should be investigated further. The advantages of this complex are as follows:

   - the requirements and costs of handling facilities for wood would be reduced;
   - electricity from the cogeneration plant could be sold to the methanol plant and to a suitable industrial user;
   - steam from the cogeneration plant could be sold to an industrial user and to the methanol plant for drying wood.

4.0 - RELATED STUDIES AND PROJECTS

In line with the growing emphasis on fuel wood consumption, the Ontario Ministry of Energy, in cooperation with the Ministry of Natural Resources, is conducting a series of studies to increase the information available regarding the use of wood as a primary fuel, including the residential, commercial and institutional markets. These studies are designed to provide analyses of fuel wood use patterns (urban and rural), consumption levels, and equipment use, fuel wood sources, and the extent of forest management involvement. This section reports on some of these recent studies and the implications for policy development.

4.1 ALGONQUIN REGION FUEL WOOD REPORT

In 1980, a survey [6] was undertaken of household fuel wood use in the MNR Algonquin Region. The survey dealt with production and consumption in the urban and rural areas of the Algonquin Region. Some of the more significant findings of the survey include the following:

1. Approximately 75% of the households used fuel wood for a variety of purposes; the strongest preference is for its use for partial heating purposes (52%), followed by total heating purposes (17%), and recreational purposes (12%).

2. The majority of fuel wood users obtained their supply from either their own lands or from private landowners (56%); only a very small percentage (10%) obtained supplies from commercial retailers. Crown land provided fuelwood for about one third of the wood users.

3. Over 61% of households using fuel wood obtained their supply by harvesting, splitting, and hauling fuel wood themselves, while only 25% purchased their fuel wood from contractors.

4. Finally, the householders who do produce their own wood have very limited heavy equipment and are, of necessity, limited in most cases to utilizing readily accessible supplies.

Results of this study are encouraging to the extent that the region exhibits a very high rate of fuel wood consumption per household. However, the region lacks an established distribution system for the provision of fuel wood in both urban and rural areas. The households continue to rely upon readily available wood, often within their own property or neighbouring lands. Moreover, the individual householders harvest, split, and transport almost all the wood they use. The relative difficulty the individual householder faces in obtaining his own wood supply could, in part, explain why wood consumption is largely devoted to partial heating purposes rather than supplying total heating fuel needs. The promotion and establishment of a better distribution network for the commercial production and distribution of fuel wood for household purposes would undoubtedly contribute to a higher level of fuel wood consumption in the region.

4.2 WOOD HEATING IN INSTITUTIONAL AND PUBLIC BUILDINGS

A June, 1981 report [7] dealt with the technical, economic and social aspects of substituting wood biomass to heat four Ontario Government complexes. Two of the complexes, Rideau Regional Centre at Smiths Falls and the Kemptville College of Agricultural Technology at Kemptville, are situated in Eastern Ontario. The other two smallest centres, the Administration and Warehousing building of the Ministry of Natural Resources near Sudbury, and the Ministry of Transportation and Communications Patrol Garage near Powassan, are located in Northeastern Ontario.

The report concludes that wood biomass conversion is favourable from an economic and employment perspective at the Rideau Regional Centre and Kemptville College of Agricultural Technology but not at the other two locations, mainly because of the economics of scale. The study reported that the scheme proposed for the Rideau Regional Centre would generate an internal rate of return of between 25% and 29%, and the scheme for converting the

TABLE 4.1

SUMMARY RESULTS OF STUDY ON

WOOD BURNING IN INSTITUTIONAL BUILDINGS

Institution	Current Fuel Consumption		Proposed Wood Heating System	
	NO.2 Oil	Natural Gas	Capital Cost	I.R.R.
	('000) Imp. gal.	Millions c.m.	($)	(%)
Rideau Regional Center	22.6	15.1	$1.9 mill.	25%
Kemptville College	201.1	—	0.79 mill.	25%

College at Kemptville would generate an internal rate of return of between 25% and 41%, depending upon the engineering technology employed. The findings of this study are summorized in Table 4.1, opposite.

The results of the study of these two centres in Eastern Ontario are very encouraging for the development of a fuel wood market for commercial and institutional buildings. This market represents an opportunity for the widespread development of the fuel wood industry in the region, and efforts should be made to continue to investigate specific institutional facilities for wood biomass conversion.

Another institution, the Grenville Christian College, located near Brockville, Ontario, is interested in developing and installing a wood-burning system to heat its present and future buildings. Fossil fuel requirements exceed 70,000 Imp. gallons/year. A study [8] was completed in 1981 covering final design and scheduling for the commissioning of a complete wood burning plant at the College. Construction of the plant is now underway.

4.3 FUEL WOOD CONSUMPTION IN ONTARIO

In January, 1981, the Ontario Ministries of Natural Resources, Energy, and Industry and Tourism initiated a study of the use of fuel wood for residential purposes in the province [9]. Using statistical sampling techniques, the study gathered empirical information for 1980 on the procurement, cost and use of wood for heating in urban and rural areas and in the north and south regions of the province.

The major findings of the study are as follows:

1. Prevalence of Wood Burning. Over one-third (36%) of the respondents burn wood at their residence in a stove, furnace or fireplace. One-quarter (26%) of the respondents use wood as a source of heat, but only 3% use wood as their sole source of heating. Of those burning wood, twice as many of the rural as urban (population of 30,000 or larger) householders burn wood in a stove, furnace or fireplace.

2. Volume of Consumption. It is estimated that in 1980, 1.22 million full cords were burned, with approximately 85% of the total, consumed in the northern regions of the province.

3. Initial Wood Burning. Respondents were questioned as to when they began burning wood. 55% of all respondents stated that they began burning wood for the first time during the four-year period, 1977-80 inclusive.

4. Fuel Replaced by Wood. 47% of the respondents used oil, and 17% used electricity prior to starting to burn wood either alone or as a supplement to fossil fuels or electricity.

5. Source of Firewood. Just less than half (45%) of the respondents got wood from their own land, 32% purchased from private landowners, 17% from the Ministry of Natural Resources and the remaining, 6% from retail sources.

6. Cost. Cost information is difficult to assess, since 59% of the sample group did not pay because the wood originated as a gift or from their own land. The average price paid during 1980 was $74 per full cord, although prices varied from $16, on average, for wood from the Ontario Ministry of Natural Resources to $83, on average, for wood purchased from retailers.

The results of this survey indicate that a relatively significant proportion of the Ontario population burn wood. Moreover, there has been a recent surge in wood consumption, as evidenced by the fact that more than 50% of the respondents started burning since 1977.

4.4 WOOD CONVERSION PROJECTS IN THE FOREST INDUSTRY

The forest industry is a major energy consumer, and efforts are being made in Ontario and elsewhere to convert wood waste on-site into useful fuels. Two recently announced projects in Ontario are the wood waste gasifier supplied by

Omnifuel Gasification System Ltd. at the Levesque Plywood mill, Hearst and the wood energy . demonstration project at Kakabeka Timber Ltd., Kakabeka Falls. Supported by federal/provincial funding, Levesque Plywood Ltd. has installed a fluidized-bed gasifier from Omnifuel to consume wood waste. It is expected that this gasifier system will replace 265 million cubic feet of natural gas currently used by Levesque Plywood Ltd. Similar joint funding is being made available to Kakabeka Timber Ltd. to convert a propane-fuelled dry kiln to a kiln fired by wood waste, using a new type of furnace featuring an automatic wood waste feeder. The use of woodwaste in this installation will completely displace the 132,000 gallons of propane used currently at Kakabeka.

TABLE 5.1

CANADIAN OIL PRICE SCHEDULE, 1982 - 1986

	Under NEP (Oct.1980)	"Old" Oil (Sept.1981)	"New" Oil
	($ per barrel)		
1982 Jan. 1	$19.75	$23.50	$47.50
July 1	20.75	25.75	50.60
1983 Jan. 1	21.75	29.75	54.50
July 1	22.75	33.75	58.50
1984 Jan. 1	25.00	37.75	61.70
July 1	27.25	41.75	65.00
1985 Jan. 1	29.50	45.75	68.40
July 1	31.75	49.75	71.80
1986 Jan. 1	35.25	53.75	75.70
July 1	38.75	57.75	79.10

Source: The National Energy Program and Memorandum of Agreement between The Government of Canada and The Government of Alberta Relating to Energy Pricing and Taxation, September 1, 1981.

5.0 - NEW POLICY INITIATIVES

The Federal Government has developed, over the past few years, a series of policy initiatives aimed at reducing oil consumption and imports. One component of these initiatives is the substitution of alternative fuel sources for oil, in particular the more plentiful renewable energy sources. This section reviews recent Federal Government action which will encourage substitution of wood for conventional fuels.

5.1 OIL PRICE AGREEMENT

The National Energy Program (NEP) provides incentives for a shift in Canadian patterns of energy use away from oil, towards gas, electricity, coal and a variety of renewable energy sources, including wood biomass. This "off-oil" conversion program is an integral part of the government's efforts towards reducing the nation's dependence upon the world oil market over the next decade. The stated goal of the NEP is the reduction in the use of oil in each of the residential, commercial and industrial sectors to 10% or less of total energy used in those sectors over the next decade[10].

The principal energy conversion incentive is the increase in the price of oil to levels that make other fuels attractive on price considerations alone. At the time of the announcement of the NEP (October, 1980), the domestic price of oil was destined to increase from $19.75 per barrel starting on January 1, 1982 to $38.75 a barrel by July 1, 1986. Subsequently, Alberta and the Federal Government have come to a new agreement which calls for higher prices for domestic oil than those stated in the NEP. Table 5.1, opposite, compares the oil price agreement under the NEP with that achieved on September 1, 1981 between the Government of Canada and Alberta. In the case of "old" oil (oil discovered prior to January 1, 1981), the domestic price is expected to increase from $23.50 a barrel as of January 1, 1982 to $57.75 a barrel by July 1, 1986. As for "new" oil, the price increase over the same period

ranges from $47.50 to $79.10. The September 1, 1981 agreement calls for Canadian prices to equal (but not exceed) 75% of world levels by 1986. As a consequence, the consumer will face rapidly increasing costs of oil, thereby establishing the compelling need to look for alternatives to oil to heat homes, and industrial and commercial facilities.

5.2 CONVERSION GRANTS

To support this drive to convert to alternative energy sources, the Federal Government also introduced, as part of the NEP, a package of incentives to assist homeowners and businesses to convert from oil. In general, the program provides grants to consumers to help cover the initial cost of conversions, providing a grant of 50% of the conversion costs up to a sum of $800. The policy is not restricted to any particular non-oil source of energy; rather, it is designed to be neutral as to the choice of the "off-oil" alternative. In addition, the Ontario Government will provide $4 million over the next three years to assist municipalities in converting facilities that currently use heating oil.

5.3 A GREATER ROLE FOR WOOD BIOMASSS ENERGY

In addition to the eligibility of renewable energy sources under the "off oil" program, there are some new and/or expanded programs specifically directed towards encouraging the use of wood energy.

The Forest Industry Renewable Energy (FIRE) program was established by Energy, Mines and Resources Canada in 1978. The program objective is to provide an incentive to industry to utilize waste forest biomass as a source of energy and thus reduce dependence on conventional, non-renewable energy sources. The government will contribute up to 20% of approved capital costs of equipment necessary for conversion to forest biomass. Up to $288 million has been allocated to the program.

At its inception, the FIRE program was directed to the forest products industry. This industry is a major consumer of fuel oil and natural gas; at the same time, it generates large amounts of combustible wood waste material

which is difficult to dispose of in many localities. For all these reasons, the forest products industry was a natural starting place for the conversion program.

The program is now being expanded to include all industrial, commercial and institutional facilities where opportunities are available to convert existing heating facilities from fossil fuels to wood waste. In addition, grants are also being made available to firms that undertake cogeneration of steam and electricity. Finally, the program is being broadened to include municipal solid waste facilities.

While the FIRE program constitutes the major federal thrust in wood conversion, other programs have also been instituted. The Energy from the Forest (ENFOR) program finances new research and development in wood biomass energy. The program deals with two segments: forestry-oriented matters such as inventory, growth, harvesting and transportation; and biomass conversion, which is concerned with the transformation of raw material into energy. Finally, the Biomass Energy Loan Guarantee Program (BELG) was established to assist cogeneration facilities; however, the program is now under review and it appears that it will be withdrawn.

The Ontario Industrial Energy Conservation and Oil Substitution Incentive Program[11] was established in 1980 to encourage oil substitution in industry. Financial assistance under this program is limited to $50,000. This program, administered by the Ontario Ministry of Industry and Tourism, may pay:

- up to 25% of the cash to cover conversion from oil to a non-oil energy source,
- up to 50% of the cash of equipment replacement and manufacturing process changes, which are more energy efficient,
- up to $1,000 for relevant professional advice.

Finally, there are two important tax incentives offered to encourage renewable energy projects. Capital equipment is exempted from federal and provincial sales tax. Certain class of equipment (Class 34) is subject to accelerated two-year write off.

In sum, the outlook for wood energy is steadily improving within the context of these recent national policy initiatives. The escalation of real prices of fossil fuels should encourage conversions to wood energy. In addition, assistance towards meeting the capital costs of converting existing facilities from oil to wood should strengthen the drive to get "off oil". For these reasons, we anticipate that the demand for wood as a source of energy should increase.

6.0 - DIRECTIONS FOR FUTURE ACTION

This study represents a preliminary analysis of the feasibility of converting wood into energy under existing economic conditions in Eastern Ontario. The study estimates the potential supply of wood at various delivered costs, reviews the existing technology and explores the market opportunities for energy derived from wood. The study has been able to demonstrate the potential for producing and using wood-derived energy in the region of Eastern Ontario. The preliminary results are generally encouraging regarding the prospects for expanding the fuel wood market, establishing a cogeneration facility, and developing a methanol facility using wood or other indigenous feedstocks in coproduction with natural gas.

However, additional work is needed on several important aspects in order to determine the commercial viability of developing any or all of these potential wood-energy industries in Eastern Ontario. The purpose of this section is to identify what still needs to be done.

6.1 THE DEVELOPMENT OF THE FUEL WOOD INFRASTRUCTURE

Although fuel wood is expected to be cheaper than oil and natural gas over the next decade, the demand for fuel wood, especially in the institutional and commercial sectors, is likely to be inhibited by several barriers. These include:

- higher handling costs and lower convenience of wood compared with those of oil and natural gas,
- the lack of suppliers able to ensure a reliable volume and quality of wood,
- the necessity of storing and financing large wood inventories.

Thus, one of the keys to the successful penetration of the institutional and commercial heating market is the development of a reliable distribution and

marketing system. Such a system would provide for the collection of wood from the various sources of supply and a consolidation of this supply at a central location for subsequent distribution to end-use markets. A component of the distribution system could be a facility for drying wood which would eliminate part of the need for on-site storage for the end-user. In addition, the system must provide for timely delivery of the fuel and the collection of residue from the process. Further work is required in analyzing the physical and economic aspects of establishing an infrastructure for the collection and delivery of fuel wood in Eastern Ontario.

6.2 COMPLETION OF THE FEASIBILITY ASSESSMENT ON ENERGY CONVERSION PLANTS

Further study is required regarding the commercial viability of the aforementioned wood-energy conversion projects in Eastern Ontario. The financial impact of varying debt/equity ratios, tax incentives, and subsidies, as well as the impact of changes in the general economic and energy price environment must be evaluated.

Should the development of wood-energy projects in Eastern Ontario prove to present no major technological and/or economic feasibility problems, successful implementation could well hinge on the resolution of other issues. Several institutional factors will influence the long-run prospects for energy from wood projects, such as:

- the nature of project's ownership, that is, whether the private and/or public sector should own the thermal and/or methanol plants; how far should public ownership proceed and what cost,

- organizational structure, including the identification of potential organizational problems for each type of facility,

- financial and tax issues relating to the raising of funds for each plant and the implications for ownership, and,

- corporate policies, such as the attitude of Ontario Hydro and municipal hydro utilities towards the purchase of power from alternative energy sources.

A thorough examination of these institutional considerations is vital to comprehensive assessment of the commercial viability of energy conversion plants in the region.

6.3 SITE SELECTION FOR COGENERATION FACILITY

We investigated the technical and economic feasibility of establishing a cogeneration (steam and electricity) facility in Eastern Ontario. The analysis was modelled on the Canada Starch Limited plant at Cardinal, Ontario as a typical example of such a facility. However, the analysis was conducted on a preliminary basis and stopped short of examining any specific site characteristics for the proposed plant. Although it appears that it is technically and economically feasible to develop a cogeneration facility in the region, this conclusion is subject to a site selection analysis and a subsequent re-estimation of capital and operating costs for that specific site.

6.4 CONVERSION OF EXISTING METHANOL PLANT

Given that there is a methanol-producing facility in the region and given the relatively high capital cost of constructing a wood-fed methanol plant, we suggest that a technical and economic feasibility study of demonstrating wood to methanol conversion in conjuction with natural gas at an existing facility be undertaken. Three basic areas should be included:

- o the technical feasibility of converting the existing naptha facility to include processing wood for the production of methanol;

- o the economic and financial viability of such a demonstration project;

- o issues related to the ownership, operation, and marketing of methanol from such a converted plant.

6.5 FURTHER INVESTIGATION OF PUBLIC AND INSTITUTIONAL BUILDINGS CONVERSION TO WOOD HEAT

The results of a recent consultant study of two Ontario Government complexes in Eastern Ontario are very encouraging for the development of wood heating and of a fuelwood market for commercial and institutional buildings.

The two complexes are: the Rideau Regional Centre at Smiths Falls and the Kemptville College of Agricultural Technology. The study reported that the scheme for the Rideau Regional Centre would generate an internal rate of return (IRR) of between 25 and 29%. The IRR for converting the College to heating with wood was between 25 and 41%, depending on the conversion technology employed.

It would appear that these opportunities warranty further investigation for demonstrating the viability of institutional heating with wood.

6.6 IMPROVEMENT IN PLANTATION PRODUCTIVITY

This study examined the economics of developing hybrid poplar plantations and concluded that wood could be produced at a delivered cost of less than $50 per ODT. More importantly, there is a potential for reducing this cost as a result of shorter cutting cycles, higher plantation and higher annual yields.

In this regard, it is encouraging to note that the Ontario Government has recently established a major research institute at Maple to study ways in which to improve the productivity of hybrid poplar. The Ontario Tree Improvement and Forest Biomass Institute has been allocated a total of $4 million for the next five years to study the breeding of fast growing trees and forest biomass production technology. The institute will focus on forest representation techniques, silvicultural methods and forest growth assessment. The institute will be managed by the Ontario Ministry of Natural Resources and funded by BILD (Board of Industrial Leadership and Development) and the Ministry.

Finally, there are two specific hybrid poplar projects currently underway. BILD is supporting a project at Carlsbad Springs involving approximately 500 hectares of Crown land for poplar production. A second project in the Cornwall area, between Domtar Inc. and the Ministry, has been approved.

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APPENDIX

CONVERSION FACTORS

1 oven-dried ton = 17 million BTU's

1 BTU = 1054 joules

1 Kwh = 3,6000,000 joules

1 gigajoule (GJ) = 10^9 joules

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